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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

THE V-22 PROGRAM'S NEED FOR A MORE FLEXIBLE AND FARSIGHTED ACQUISITION STRATEGY

MAJ ALAN J. BACON 88-0145

"insights into tomorrow"

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TITLE THE V-22 PROGRAM'S NEED FOR A MORE FLEXIBLE AND FARSIGHTED ACQUISITION STRATEGY

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In order to control runaway acquisition costs, Congress frequently insists that the DOD develop and procure its major weapons systems with firm fixed-price contracts. These contracts work well for controlling costs of systems with few unknowns and low technological risks. However, in the case of the V-22 Osprey, a system whose three relatively new technologies could have many unknowns and high risks, a long-term fixed-price contract may not be a good idea. In addition to showing that the V-22's current fixed-price contract may not be able to contend with its potential engineering problems, this study provides recommendations for developing a more flexible and farsighted acquisition strategy for the V-22.

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PRFFACE

In response to the DOD's runaway acquisition costs of the 1960's and 1970's (e.g., the $3.3 billion/114 percent cost overrun of the F-111), Congress routinely insists on fixed-price contracts for controlling these costs. Fixed-price contracts can keep acquisition costs from skyrocketing during production. They can effectively regulate costs of systems with few unknowns and low technological risks. However, in the case of the multi-service V-22 Acquisition Program, a long-term fixed-price contract is not a good idea. This paper will show that the unknowns and risks associated with V-22's new technologies require that the Osprey be procured with a more flexible and farsighted acquisition strategy.

As a forerunner of the DOD's aviation acquisition programs, the V-22 Program will probably undergo several purchasing changes. For example, in mid-January 1988, the Army, which desperately needs its aviation dollars to replace its aging helicopter fleet, cancelled its plans to buy the expensive V-22. Regardless of this cancellation or any future changes in V-22 buys, the thesis of this paper remains intact. The V-22 is a major DOD weapons system seriously in need of a more flexible and farsighted acquisition strategy.

In addition to thanking my ACSC faculty advisor, Major Don Ottinger, I would like to thank the aeronautical engineers at the U. S. Army Safety Center and the participants at the V-22 System Safety Working Groups for their insights into the complex issues affecting the "high tech" Osprey.

ABOUT THE AUTHOR

Major Bacon is a student at the Air Command and Staff College, Maxwell Air Force Base, Alabama. Prior to earning a Bachelor of Science in General Engineering from the U. S. Military Academy, he served an enlisted tour as an Intelligence Analyst and Vietnamese Language Student. In 1984 he was awarded a Master of Science in Aerospace Engineering from Texas A&M University where he concentrated on aircraft structures and advanced composite materials. Major Bacon's military schooling includes the Infantry Officer Basic Course, the Intelligence Officer Advanced Course, Airborne School, Ranger School, and the Army's rotary wing and fixed wing aviator qualification courses. He has worked in a variety of command and staff positions in infantry, aviation, and intelligence units within the 4th Infantry Division, the 25th Infantry Division, and III Corps. In III Corps at Fort Hood, Texas, he served as a company commander and battalion operations officer (S-3). Most recently, Major Bacon worked as an aeronautical engineer at the U. S. Army Safety Center, Fort Rucker, Alabama, where he evaluated safety-related engineering issues of numerous air and ground systems to include the V-22 Osprey, UH-60 Blackhawk, AH-64 Apache, AH-1 Cobra, OV-1 Mohawk, Remotely Piloted Vehicle, and 155mm Howitzer.

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LIST OF ILLUSTRATIONS

GLOSSARY

ACSC - Air Command and Staff College

AFIT - Air Force Institute of Technology

AVSCOM - Aviation Systems Command

DSARC - Defense Systems Acquisition Review Council

FLIR - Forward Looking Infared

FSD - Full Scale Development

GPS - Global Positioning System

LHX - Light Helicopter Experimental

LIC - Low Intensity Conflict

LRU - Line Replaceable Unit

MIL-STD - Military Standard

MSIP - Multi-stage Improvement Program

nicad - nickel cadium

NOE - nap-of-the-earth

OEI - One Engine Inoperative

PM - Program Manager

PPBS - Planning, Programming, and Budgeting System

SPO - System Program Office

SSWG - System Safety Working Group

TEI - Two Engine Inoperative

USASC - U. S. Army Safety Center

EXECUTIVE SUMMARY

REPORT NUMBER 88-0145

AUTHOR(S) MAJOR ALAN J. BACON, USA

TITLE THE V-22 PROGRAM'S NEED FOR A MORE FLEXIBLE AND FARSIGHTED ACQUISITION STRATEGY

I. Purpose: To show that the V-22's long-term fixed-price contract strategy may not be able to contend with its potential engineering problems and to provide recommendations for a more flexible and farsighted acquisition strategy.

II. Problem: In response to DOD's acquisition "horror stories" of the 1960's and 1970's, e.g., the $3.3 billion 114 percent cost overrun of the F-111, Congress frequently insists that major DOD weapons systems be developed and procured with fixed-priced contracts. Fixed-priced contracts are good for systems with few unknowns and low risks. However, in regards to the V-22, a long-term fixed-price contract may not be a good idea. The V-22's three relatively new technologies, i.e., tilt rotors, all composite airframe, and fly-by-wire controls, could involve several unknowns and high risks.

III. Data: Problems in the following areas could degrade the operational effectiveness and safety of the Osprey: (1) fuselage crashworthiness standards, (2) crew seat design, (3) fuel cell burst characteristics, (4) proprotor blade impact, (5) engine heat, (6) lead-acid battery, (7) weather radar, (8) throttle quadrant, and (9) wire-strike protection. Additionally, the aircraft's contract and acquisition strategy does not have any provisions for making major changes in the aircraft's production line. Aside from making minor configuration changes, its strategy cannot incorporate major "lessons learned" or new engineering research into the V-22's production. There are no plans for a V-22 block improvement program.

IV. <u>Conclusions:</u> The V-22 will probably have some engineering problems that can be eliminated only with monies beyond its contract.

V. <u>Recommendations:</u> After the current V-22 contract expires, the V-22 Program Manager should adopt a Multi-stage Improvement Program (MSIP) acquisition strategy similar to the Air Force's F-16 MSIP strategy. In addition to correcting the issues cited above, a V-22 MSIP could incorporate "lessons learned" and engineering research into the V-22 production line.

Chapter One

INTRODUCTION

HISTORICAL CASE FOR THE V-22 OSPREY

On the morning of 25 April 1980, after their unsuccessful hostage rescue attempt in Iran, the United States' Delta Force was returning to Egypt. (3:280-281) While sitting dejected aboard a C-141 Starlifter aircraft, Colonel Charlie Beckwith, the commander of the rescue mission, thought to himself,

> It's over. The mission is a failure.... After all that time and work and sweat, to come away empty. I began to realize what the failure would mean. Our country will be embarrassed. We lost eight good and brave men. And now, what will become of the hostages? God Almighty, after all the effort, here we sit returning to Egypt - all because of those bloody helos. (3:281)

The "bloody helos" Beckwith cited were RH-53 Sea Stallion helicopters. Due to their range limitation of approximately 700 miles, the RH-53s were unable to make the 900 mile flight from the USS Nimitz in the Gulf of Oman to the hostage site in Teheran. Consequently, they had to be refueled at Desert One approximately 300 miles southeast of Teheran. (3:216) Eight RH-53s were launched from the Nimitz to ensure that six would be operational at Desert One. (3: 233) If six "helos", the minimum for carrying Beckwith's assault team and equipment, were not ready to fly from Desert One, the mission would be aborted. (3:253) Unfortunately, one RH-53 aborted just two hours after launching. One of its main rotor blades was about to malfunction. Another returned to the carrier due to instrument problems caused by flying through some sandstorms. (3:283) A third RH-53, taking off from Desert One, slid backwards and crashed into a parked EC-130 Hercules. (3:278) With only five helos remaining, the mission was aborted. (3:281)

Beckwith's "bloody helos" were indeed the weak link in the operation. At that time, the Delta Force did not have an aircraft capable of accommodating the weight and flight requirements of the Iran rescue mission. The 900 miles of desert exceeded the operational ranges of all helicopters. A transport aircraft, such as the C-130, was not acceptable because it could be easily detected when landing near Teheran. Beckwith needed an aircraft capable of landing and taking off in a small secure area and flying undetected over a great distance. Beckwith needed an aircraft with the capabilities of the multi-service V-22 tilt-rotor aircraft currently undergoing acquisition. With tactical aerial refueling capabilities similar to the C-130's, the V-22 could have flown secretly across the Iranian desert at 250 knots in its airplane configuration, transformed to its helicopter mode, and landed undetected in a secure confined area near Teheran. (10:G-8; 20:--)

IMPORTANCE OF THE V-22 TO THE DEFENSE OF THE U. S.

As proposed, the V-22 will fill the void between short-range helicopters which can land in small areas and long-range troop transports which require large landing strips. In addition to "Delta Force" type operations, the Osprey will perform assault, rescue, transport, and many other missions for our armed forces. (10:G-1) The "high tech" V-22, built with three new or relatively new technologies (i.e., tilt rotors, all composite airframe, and fly-by-wire controls), will provide the United States (US) new dimensions in military and political power. Paramount of which will be the capability to insert combat power into previously impossible-to-reach regions, thereby giving the US the power and deterrence to contend with terrorist groups and hostile third-world nations active in low-intensity conflicts (LICs). LICs are generally limited to geographic areas, weapons constraints, and low levels of violence as compared to conventional military conflicts. (1:7) Nonetheless, these limited conflicts have had and will continue to have major impacts on US national interests and world order. Since World War II, over 700 countries have been involved in armed conflicts. Eighty percent of these have been LICs. (25:--) In 1987, fifty percent of all third-world countries were involved in LICs. (30:--) Hence, the Department of Defense's (DOD's) skillful acquisition of the V-22 is paramount to the US's capability to contend with future LICs such as the Iran hostage situation.

THE V-22's CURRENT ACQUISITION STRATEGY

In response to the acquisition "horror stories" of the 1960s and 1970s, e.g., the $3.3 billion/114 percent cost overrun of the F-111, Congress routinely insists on fixed-price contracts for acquisition programs. (2:4-21) Fixed-price contracts are good for controlling systems with few unknowns and low risks because these contracts can curtail sky rocketing production costs. (31:--) However, in the case of the V-22, a system whose three new technologies have many unknowns and high risks, a long-term fixed-price contract strategy for procuring several hundred aircraft through the 1990s, may not be a good idea. (6:29) Nonetheless, the US Navy, as the lead service for the V-22 Program, has opted to fund the Osprey with this type of acquisition strategy. (24:--; 27:--; 28:--; 29:--)

At this time, the V-22's fixed-price contract will most likely have a negative impact on this critical acquisition program. The V-22 will probably have some engineering problems that can be eliminated only with monies beyond its contract. If uncorrected, these problems could degrade the operational effectiveness and safety of the Osprey.

PURPOSE AND OVERVIEW

The purpose of this paper is twofold. In addition to showing that the V-22's fixed-price contract may not be able to contend with the V-22's potential engineering problems, this paper will provide recommendations for a more flexible and farsighted acquisition strategy. This will be accomplished by first providing a description of the aircraft and a status of the V-22 Program in Chapter Two. Chapter Three will identify some of the V-22's potential engineering problems. The Osprey's acquisition shortcomings will be covered in Chapter Four. Chapter Five will provide conclusions and recommendations. Besides rendering recommendations for a more flexible and farsighted acquisition strategy, Chapter Five will present specific recommendations for correcting the engineering problems identified in Chapter Three.

Chapter Two

THE V-22 OSPREY PROGRAM

DESCRIPTION OF THE AIRCRAFT

The Bell-Boeing V-22 Osprey Program (see aircraft at Figure 1, page 7) is one of the most ambitious aviation acquisition programs in history. The challenge of integrating three new or relatively new technologies (i.e., tilt rotors, all composite airframe, and fly-by-wire digital controls), makes the V-22 Program one of our "highest tech" aviation acquisition programs. At this date, the Osprey's tilt-rotor technology has yet to be integrated successfully into either a commercial or military aircraft. The V-22's engineering test bed, the Bell/NASA/Army/Navy XV-15 research aircraft (see Figure 2, page 7), constitutes the only practicable demonstration of this technology. However, as compared to the V-22, the XV-15 was much smaller and built to much less stringent specifications. (28:--) The Osprey's primary structure will be made with state-of-art Hercules IM6 and 3501 graphite-epoxy composite materials. (4:47) The V-22, like many of our new aircraft (e.g., the F-16), will be controlled with a sophisticated fly-by-wire control system. This system will be composed of a primary digital control system and a backup analog control system. (22:--)

As a hybrid helicopter/fixed wing transport aircraft, the Osprey will be capable of taking off and landing in confined areas in its helicopter mode and transforming to high-speed fuel-efficient flight in its airplane mode. As shown in Figure 3, page 8, the V-22's flight envelope will encompass the envelopes of both the HH-53C helicopter and the C-130 transport aircraft. The V-22 will be able to sustain cruise flight at 250 knots, accelerate to 320 knots, carry 24 combat troops, and hover at 3,000 feet at 91.4 degrees F with a full load. (5:7) As a large 43,000 to 60,000 lb. aircraft (see Figure 4, page 8 and Figure 5, page 9), it's fuselage size and troop capacity will be about the same as the Marine Corps' C-46 Helicopter. Nevertheless, the V-22's capacity will be much lower than the C-130's 92 combat-equipped troop capacity. (20:--) While being self-deployable overseas (see Figure 6, page 9), the Osprey will be able to fly 2100 nautical mile legs, without refueling, against prevailing head winds. (10:G-6)

As replacements for several of our aging helicopters and fixed-wing transport aircraft, V-22s will provide our aviation units with tremendous improvements in their operational capabilities. Ospreys will be used for medium assault in the Marine Corps, combat search and rescue in the Navy, and special operations in the Air Force. (10:G-1)

STATUS OF THE V-22 ACQUISITION PROGRAM

On 17 April 1986, a Defense Systems Acquisition Review Council (DSARC) approved the V-22 Program for full-scale development (FSD). The Navy, as the lead service of this multi-service program, then awarded Bell Helicopter Textron and Boeing Vertol, as joint contractors, a $1.8 billion fixed-price FSD contract. (4:47) This contract calls for producing components of 11 equivalent aircraft, a ground test vehicle, six test-flight aircraft, and the major assemblies for tooling, structural testing, and ballistic testing. (4:46) Once completed, these tooling assemblies will lock the V-22 design for several hundred aircraft in "concrete". (24:--)

At this time, the Navy Program Manager (PM) has no plans for modifying his long-term fixed-price contract acquisition strategy. While not providing for a systematic block improvement program, i.e., a V-22B, the PM has no plans for major airframe or power-plant improvements. Aside from Pre-Planned Product Improvements, he does not have a methodology for fixing major "lessons learned" or incorporating new engineering research into the production line. (24:--) Notwithstanding that the V-22 will be, ".... an almost-all composite tilt-rotor aircraft, something no one has done before. (4:46)", the acquisition calls for no major changes in the V-22 production line, i.e., the first aircraft in Lot 1 will be basically the same as the last aircraft in the final lot. (24:--)

Test flights for six V-22 FSD aircraft are scheduled to commence in the spring of 1988. (22:--) Production of the actual aircraft will begin in 1989 with deliveries to the Marine Corps in 1991 and to the Navy and Air Force in 1993. The Marines are committed to purchase 552 Ospreys; the Navy, 50; and the Air Force, 80. (16:4) In mid-January 1988, the Army, which desperately needs it aviation dollars to modernize its aging helicopter fleet with Black Hawks, Apaches, the new Light Helicopter Experimental (LHX), cancelled its plans for buying the expensive V-22. (7:36) With an original commitment to buy 231 Ospreys, the Army has yet to receive Congressional approval for its recent cancellation. (19:--) Nevertheless, the V-22 PM, who plans to offset the Army loss with foreign military sales of 500 to 600 Ospreys, believes the Army "pull out" will not jeopardize the program. He also believes that the Army, who will continue to monitor the V-22 Program, will "sooner or later" buy the Osprey. (7:36) At this time, the V-22's cost is expected to be as high as $29 million per aircraft. (6:29)

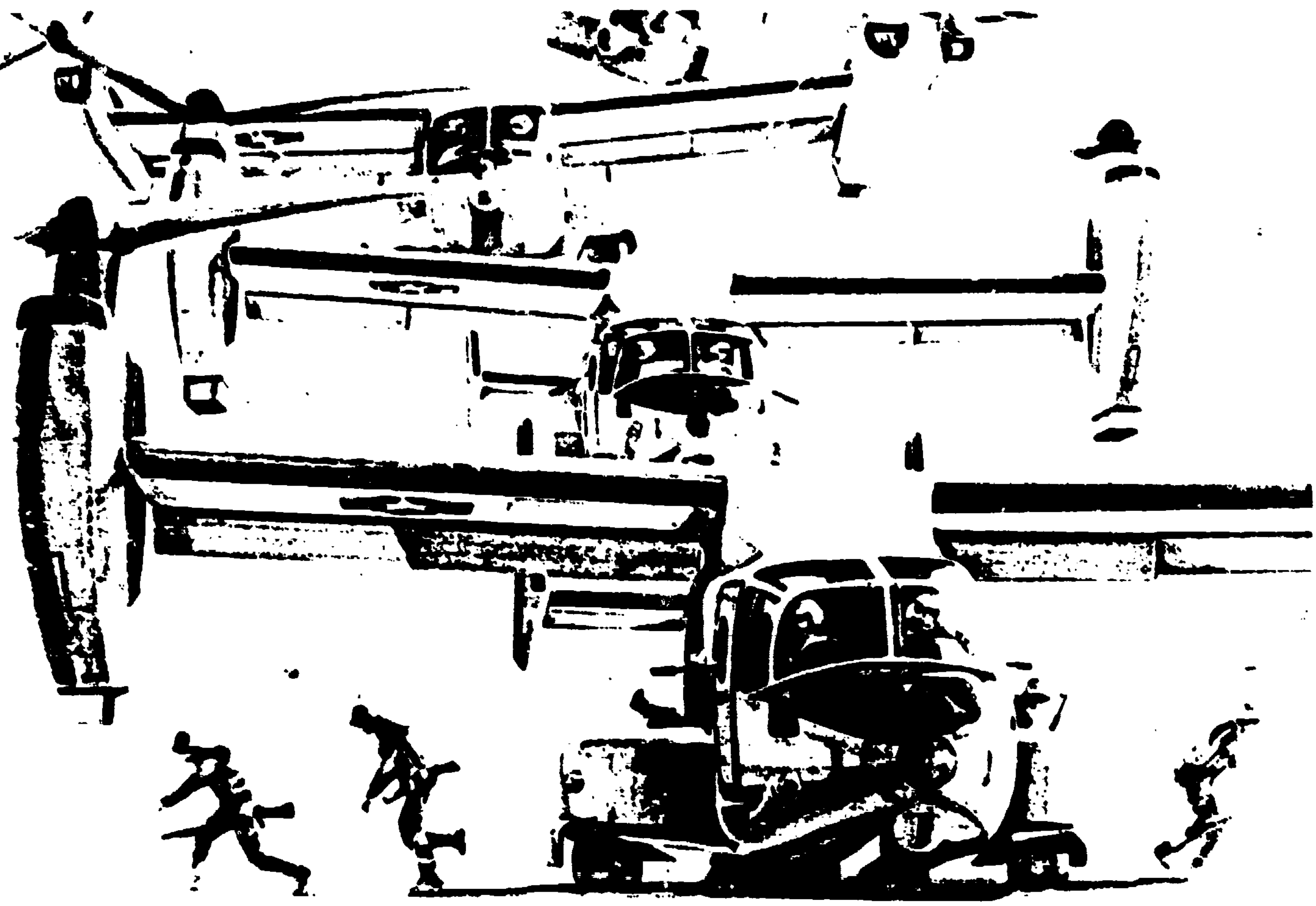


Figure 1. V-22 Osprey

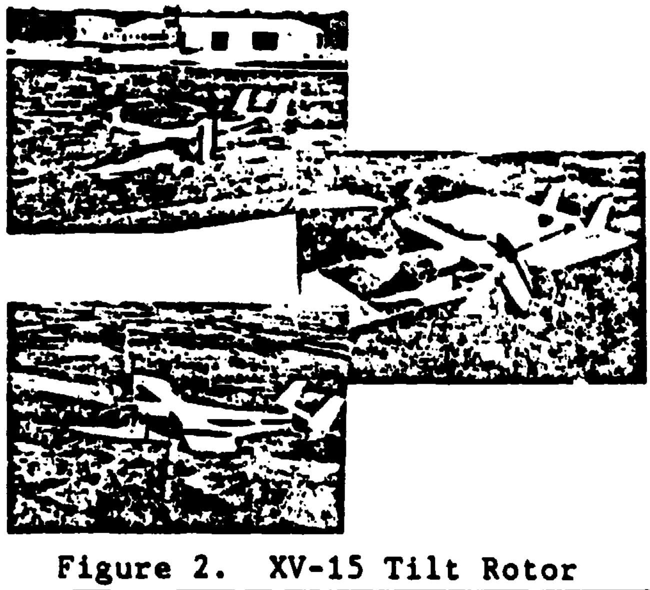


Figure 2. XV-15 Tilt Rotor

Figure 3. V-22 Flight Envelope

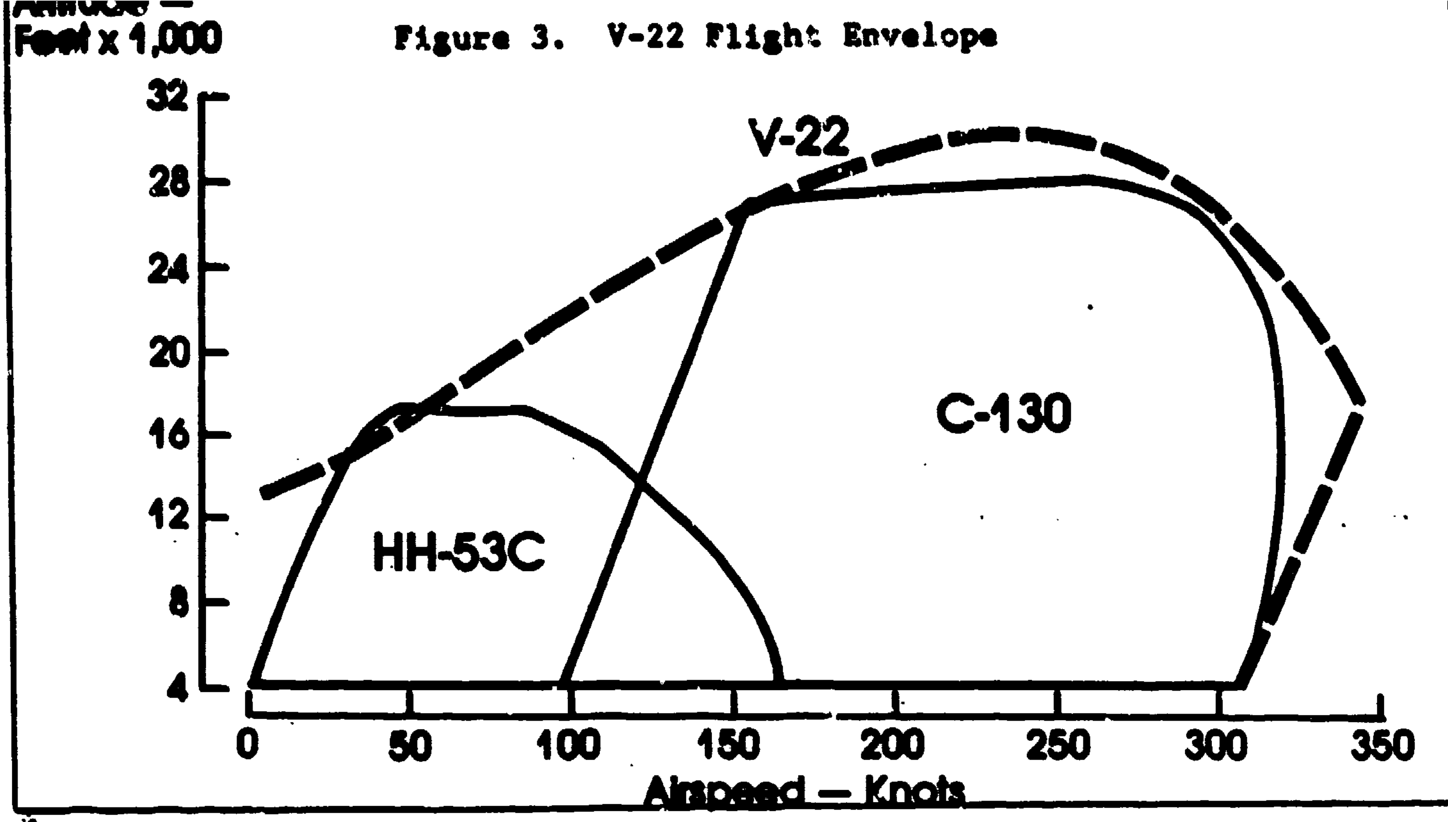
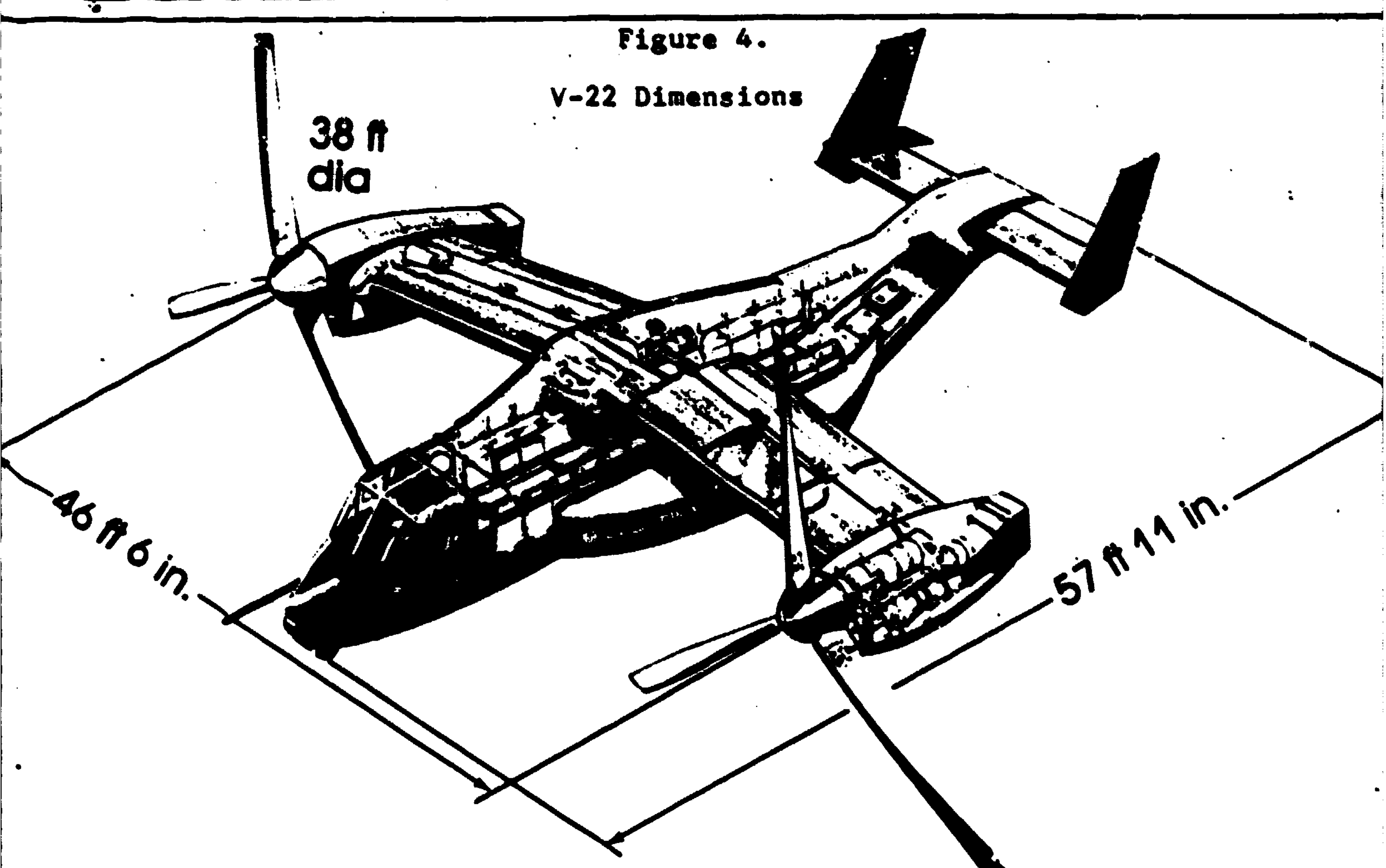


Figure 4.

V-22 Dimensions



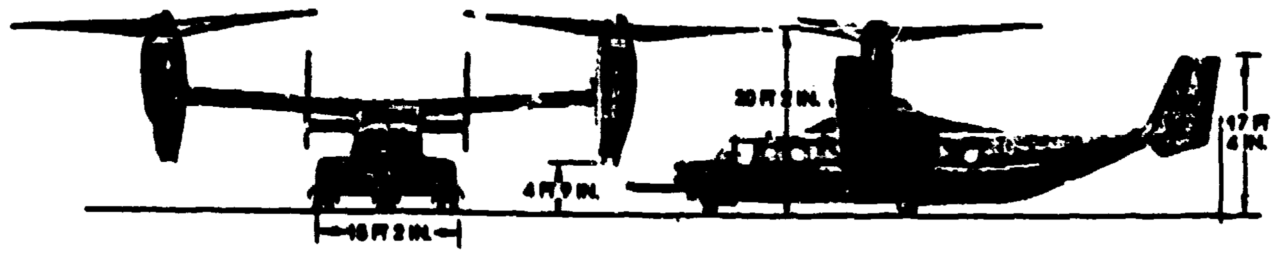


Figure 5. V-22 Dimensions

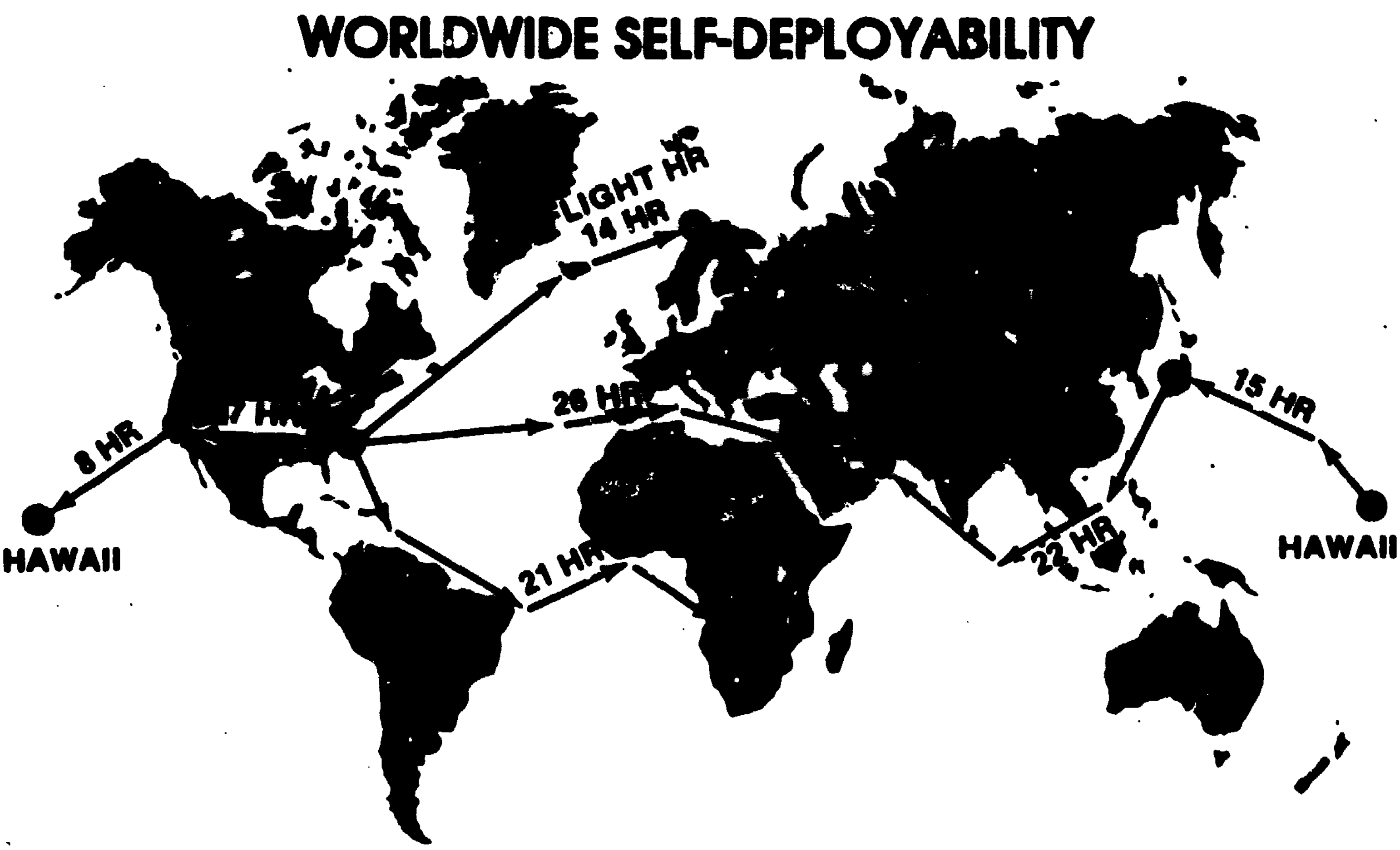


Figure 6.

Chapter Three

V-22's POTENTIAL ENGINEERING SHORTCOMINGS

The Osprey's potential engineering shortcomings fall into two general categories--crashworthiness problems and configuration issues.

The origin of the fuselage crashworthiness problems cited in this chapter are directly related to the V-22 Program's fixed-price contract. The aircraft's crashworthiness has undergone a series of reductions because the contractors were not willing to assume the risks and costs of achieving higher levels of crashworthiness under the constraints of a fixed-price contract. However, with the flexibility of a cost-plus contract, Bell and Boeing would have been willing to work toward higher levels of crashworthiness. (18:1)

The other crashworthiness problems as well as the configuration issues cited in this chapter are indirectly related to the aircraft's fixed-price contract in that they can be eliminated with additional monies. However, these issues were not considered during the contract negotiation process. (28:--)

CRASHWORTHINESS PROBLEMS

Fuselage Crashworthiness Standards.

The PM contends that V-22's fuselage crashworthiness is, "equal to or better than the crashworthiness of any aircraft of similar weight and performance". (28:--) He originally required the contractor to meet the crashworthiness standards of Military Standard (MIL-STD) 1290. However, he now contends that these standards are not practical for the V-22's weight range of 43,000 to 60,000 lbs. (28:--)

The V-22's current level of crashworthiness will most likely endanger the lives and safety of its aircrews and passengers. "Being equal to or better than the crashworthiness of any aircraft of similar weight or performance" is not good enough. (28:--) The Osprey's crashworthiness may not be commensurate with its performance characteristics and likely mission scenarios. Since all of the vertical attenuation is placed in the landing gear, a crew member will be afforded negligible crashworthiness in the event of a gear-up crash and a crew-seat binding failure. (9:--; 13:--) He will be provided little stroking distance (cushion) to dissipate his kinetic energy upon collision, thereby causing him to suffer from higher G forces during impact. Considering that few Army helicopter Class A mishaps involve landing scenarios, the contractor's heavy reliance on the V-22's gear-down landing protection may be invalid for most V-22 crashes in the helicopter mode. (14:--)

Compounding the gear-up crashworthiness problem are unknown rates of descent for One-Engine Inoperative (OEI) and Two-Engine Inoperative (TEI) emergencies. These rates may not be available until completing the V-22's initial test flights in the spring of 1988. (29:--) Once determined these rates should be correlated with the fuselage's crashworthiness standards, i.e., the fuselage should be designed to minimize the severity of OEI and TEI impacts.

The Osprey's fuselage crashworthiness standards have been continually reduced from its original MIL-STD 1290 specification. (11:--; 28:--) The first reduction involved lowering the V-22's vertical-velocity attenuation from 42 to 36 feet per second. (28:--) Pitch, roll, and yaw impact requirements were subsequently eliminated. (28:--) Eventually, the vertical velocity was lowered to 24 feet per second with all the attenuation placed in the landing gear. (28:--) As result of a modification to the Navy standard for crashworthiness, the contractor is authorized to merely meet MIL-STD 1290 to the "maximum extent practical" rather than to strictly comply with the standard. (9:--; 27:--; 28:--; 29:--)

Paralleling the reduction in fuselage crashworthiness standards was a relaxation in the aircraft's fuselage design. Most significant of these relaxations was the substitution of a previously accepted Kevlar honeycomb energy-absorbing underfloor with an extremely stiff and brittle graphite laminate structure. (9:--; 27:--; 28:--; 29:--) This sacrificed a dedicated energy attenuating crush space for a stiff composite structure having unknown energy attenuating capabilities. Unlike metallic structures, composite structures, with their complex elastic and dynamic qualities, cannot be accurately evaluated for likely crash sequences with mathematical predictions alone. Composite crashworthiness can only be ascertained through testing.

Amplifying this problem is the Navy contract which does not require the contractor to dynamically crash test the underfloor. (27:--; 28:--; 29:--) At this point, it is impossible to project aircraft losses and accident costs attributable to insufficient crashworthiness. Accurate trade-off analyses, with pitch and roll variations, are not available which consider fuselage impact at design sink speeds after fully compressing the landing gear or crashing the aircraft with its gear up. While the contractor's mishap analysis shows a crashworthy underfloor would have benefited crew members and passengers in only 12% of all H-46, H-47, and H-53 Class A mishaps, the analysis is incomplete. (29:--) It fails to evaluate all potential V-22 Army, Navy, Marine, and Air Force crash sequences with respect to service-unique mission scenarios. Overall crashworthiness testing and analyses conducted by the contractors to date are insufficient. Expected mishap frequencies and foreseeable accident costs of operational V-22 mission scenarios are yet to be adequately defined by the PM or the contractor.

<u>Crew-Seat Design</u>.

Rail-guided crew seats, similar to those proposed for the V-22, are susceptible to binding and stroking failures. As discussed above, a crew-seat failure combined with a stiff underbelly in a gear-up crash equates to zero or near zero vertical absorption. Crew members in this situation will be afforded little if any crashworthiness protection. (9:--; 13:--)

<u>Fuel Cell</u>.

The V-22's flexible rubber fuel tanks may be susceptible to puncture and tear. Upon impact, sharp or jagged portions of the composite structure could penetrate the cell or cause the tank to burst. Since the dynamic crash characteristics of the fuselage are unknown, the cell's ability to remain in tact during a crash sequence can only be demonstrated with a full-scale drop test while the tanks are mounted in the airframe. At this time, there are no provisions for a test of this type. (9:--; 12:--; 13:--)

<u>Proprotor Blade-to-Wing Impact</u>.

While the <u>V-22 Full-Scale (FSD) Development Crashworthiness Assessment</u> cites the potential for a blade-to-wing impact, it does not address blade impact hazards and subsequent fire dangers to V-22 crew members or passengers. Considering that the Osprey's wing-borne fuel cells are mounted in the vicinity of the V-22's high RPM proprotors (the V-22's combination airplane propeller and helicopter rotor blade), this accident scenario needs to be evaluated. (9:--; 13:--)

AIRCRAFT CONFIGURATION ISSUES

Engine Heat.

In System Safety Working Group (SSWG) No. 8, the contractor briefed a V-22 engine exhaust profile, with temperatures extremes of 575 degrees F, thereby making the aircraft unsuitable for safuly landing or hovering in unimproved sites where vegetation or combustible materials exist. In SSWG No. 9, the contractor provided a new chart, based on mathematical approximations, which predicted much lower heats. The contractor asserted that the new heats would not be a safety factor in these situations. (28:--)

Notwithstanding these lower heat predictions, detailed tests of the V-22 exhaust plume should be conducted to accurately evaluate its heat profile. If the aircraft's actual temperatures are excessive, the V-22 Forward Looking Infrared (FLIR) system and all standard aviation night vision goggle devices could be ineffective. V-22 crews could experience degradations in their night vision fields-of-view due to engine heat. Consequently, safe conduct of nap-of-the earth (NOE), sling load, and confined area operations may not be possible at night.

Lead-Acid Battery.

A lead-acid battery in lieu of a traditional nickel-cadmium (nicad) battery will power the aircraft's D.C. electrical system. Historically, lead-acid batteries are notorious for unreliability and power fluctuations in severe hot/cold environments. With the preponderance of its subsystems dependent upon electrical power, the V-22 will need a highly reliable battery in all environments. (21:--; 26:--)

Weather Radar.

Absence of a weather radar in long-range, over-water, or self-deployable flights could place V-22 aircrews in jeopardy when flying near or through severe weather. In many cases, thunderstorms, hail, ice, and heavy snow cannot be properly detected, diagnosed, or avoided without weather radar. Sandstorms, similar to those encountered during the Iran hostage rescue attempt, cannot be avoided without an on-board weather radar. Considering that many self-deployments will not have air traffic control radar support, weather radar will be needed in most overseas areas. (23:--)

Throttle Quadrant.

V-22 throttle/power movements are opposite to helicopter collective/power movements. Negative helicopter-habit transfer could cause the average V-22 pilot with considerable helicopter experience, in a life-threatening situation near the ground, to move the throttle quadrant in the wrong direction. (29:--)

Wire-Strike Protection.

The Osprey's lack of wire-strike protection could lead to unnecessary aircraft and aircrew losses. Wire strikes at low level, contour, and NOE altitudes are highly probable on the modern battlefield. Expected wire hazards include control wires from wire-guided munitions, communications wires, power lines, and enemy wire "booby traps". Historically, both fixed-wing and helicopter crews alike suffer high percentages of fatalities after striking a wire(s). Reports on these accidents show that wire-strike protection is needed to cut and channelize wires away from critical flight control components. (14:--; 28:--)

After conducting a detailed study on wire strikes, the Army installed wire-strike protection devices on most of its tactical helicopters. (14:--; 28:--) Using these "lessons learned" as justification, the PM should incorporate wire-strike protection into the V-22 Program.

RESOLUTION OF THESE SHORTCOMINGS

In lieu of a piecemeal resolution of these engineering shortcomings, a strategy which is most likely beyond the capabilities of the current contract, the PM should adopt a more flexible and farsighted acquisition strategy to systematically fix these problems. Step one of this process involves recognizing the constraints of the current V-22 acquisition strategy. Chapter Four will identify these constraints.

Chapter Four

ACQUISITION STRATEGY SHORTCOMINGS

Even though a long-term fixed-price contract can curtail runaway acquisition costs during production, a firm fixed-price strategy from FSD through production for procuring several hundred V-22s through the 1990s is not a good idea. Fixed-price contracts are good for systems with few unknowns and low risks. They can curb sky rocketing production costs. However, the V-22's simultaneous implementation of three new or relatively new technologies, i.e., all composite airframe, fly-by-wire controls, and tilt rotors, most likely involves risks which are much higher than those of other major acquisition programs. This chapter will discuss constraints in the V-22 acquisition strategy which reduce the program's ability to contend with the V-22's technological risks and unknowns.

Considering that many of these risks will not be resolved until completion of its upcoming developmental and operational testing (DT and OT), the V-22's risks could prove to be beyond the scope of its constrained strategy. First of all, the contractor's risks for integrating the V-22's new technologies into the program could be too high or too low with respect to the value of the contract. Secondly, neither the contractor nor the government may have a good appreciation of the program's actual risks. Neither may know a fair price for the aircraft. Thirdly, the contractor could be charging the government for assuming these risks. (17:--) Lastly, there are no clauses within the contract for taking advantage of "lessons learned" or engineering research that pertains to the V-22's three new technologies. There are no provisions for incorporating "lessons learned" or new research into the V-22 production line, i.e., there are no plans for a block improvement program. (24:--)

Good examples of potential engineering research which may be beneficial to the program are listed in NASA's <u>International Aerospace Abstracts</u>. In 1986, this abstract listed over 800 research items applicable to advanced composite materials. Research breakthroughs such as composite material environmental effects, fatigue characteristics, and non-destructive damage detection could be helpful to the V-22 Program. (8:--) However, at this time, none of this research can be integrated into the V-22's production line. Considering the volume of V-22 technical unknowns which could be resolved by engineering research and DT/OT "lessons learned", it is imperative for the PM to make provisions for incorporating this knowledge into the V-22 Program.

An acquisition strategy's flexibility is furthermore important in controlling the costs of engineering design changes. The DOD's experience has shown that engineering changes costing $1 in concept exploration or $1 in demonstration and validation require implementation costs of $10 in FSD, $100 in production, and $1,000 after deployment. Experience has also shown that special tools and test equipment for new technologies can cost more than 250 times the cost of their production parts. (15:--) It is important to "get it right the first time", but in many cases this is impossible to accomplish when working with the unknowns of new or relatively new technologies.

"It is incumbent upon the PM to develop an acquisition strategy tailored to his particular program. .... Initially, the strategy may be limited, but it should be expanded and refined as the program progresses". (2:4-10) Now is the time for the PM to expand his strategy. Now is the time for the PM to develop a more flexible and farsighted strategy.

In light of this paper's sound argument for changing the V-22's long-term fixed-price contract strategy, the PM still must satisfy Congressional pressures for maintaining a fixed-price contract. Chapter Five will show that the PM is not in a "no-win situation". Chapter Five will show that the PM can adopt a more flexible and farsighted strategy capable of both satisfying Congress and resolving the engineering and technology problems identified in this paper.

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

As shown, a long-term fixed price contract is not a good acquisition strategy for the critical multi-service V-22 Program. The V-22's contract and new technologies could involve risks which are too high for the government, the contractor, or both. The aircraft's operational effectiveness and safety could be degraded with engineering shortcomings requiring monies beyond the V-22's contract to correct. Additional contract shortcomings involve no provisions for incorporating "lessons learned" or engineering research pertaining to the V-22's new technologies into the V-22 production line. (24:--)

RECOMMENDATIONS

This chapter will provide recommendations for a more flexible and farsighted acquisition strategy as well as recommendations for eliminating the potential engineering shortcomings cited in Chapter Three.

Acquisition Strategy Recommendations.

Recommend the V-22 PM look to the Air Force F-16 System Program Office (SPO) for a more flexible and farsighted V-22 acquisition strategy. While satisfying Congress with a short-term fixed-price contract approach, the Air Force is growing their "high tech" F-16 through a Multi-stage Improvement Program (MSIP). The MSIP is advantageous to both the government and the contractor in that it sufficiently controls the program's risks with a firm fixed price. It is flexible because the F-16's fixed-price contract with incentives is re-negotiated with Congressional backing every four years. This four-year re-negotiation process is effective because it enables the Air Force to directly coordinate Congressional budget approvals within the cycles of the Planning, Programming, and Budgeting System (PPBS). It is farsighted because it incorporates "lessons learned" modifications and new engineering research into the aircraft within three blocks of improvement. The MSIP Block One will benefit F-16 A's and B's. It will provide installation points for Line Replaceable Units (LRUs), i.e., avionics components and other "black boxes". It will also provide for stronger aircraft structural members to include stronger wings, an environmental cooling system, new ducting systems, and more ordnance hard points. Block Two provides for the emplacement of difficult-to-install wiring harnesses into F-16 C and D models. Block Three will install the Global Positioning System (GPS) and all new LRUs. (17:--)

Recommend the V-22 PM procure his FSD aircraft as planned. Further recommend he adopt a re-negotiable, block improvement acquisition strategy similar to the F-16's strategy. While the argument for a new V-22 strategy directly parallels the rationale for the above F-16 strategy, a new V-22 strategy, i.e., a V-22 MSIP, could eliminate the shortcomings of the V-22's long-term fixed-price contract cited in Chapter Four.

Engineering Shortcoming Recommendations.

Recommend the V-22 PM incorporate the recommendations below within the provisions of the proposed V-22 MSIP.

Fuselage Crashworthiness Standards.

(1) Coordinate modifications to the V-22 design which adhere to MIL-STD 1290 and provide adequate underbelly energy attenuation; or,

(2) Coordinate adequate structural testing, engineering modeling, and trade-off studies. Coordinate mishap scenario studies similar in scope to the related-source references on the LHX. Base these studies on gear-up and gear-down accident cost comparisons involving the original V-22 design, the FSD aircraft, and a MIL-STD 1290 aircraft. Give senior decision makers sufficient information to accept the current V-22 design with its crashworthiness risks or justification to negotiate critical design changes.

Crew-Seat Design. Ensure that adequate dynamic testing of the current design is conducted to demonstrate that the seat will contend with expected forces for all impact scenarios. Coordinate a design change if necessary.

Fuel Cell. Test the Osprey tank design for crashworthiness. Conduct full-scale tank drop testing, with tanks mounted in the airframe, to demonstrate fuel containment while the tanks are exposed to nearby structural deformations and fractures.

Proprotor Blade-to-Wing Impact. Test and perform accurate trade-off analyses for this crash scenario.

Engine Heat. If testing proves that the V-22's exhaust heat is unacceptable, consider mounting the engines in the upper rear fuselage area (similar to the engine positions of A-10 and the CH-47) on future models of the V-22, i.e. the V-22B.

Battery. Test the performance of the V-22's lead-acid battery in severe environments. Emphasize monitoring power fluctuations and total losses of battery power on the Osprey's system performance.

Weather Radar. Explore the ramifications of adding a weather radar to the V-22. Consider the Army's U-21 or C-12 weather radars as potential V-22 weather radar candidates to minimize costs.

Throttle. Review DT and OT flight tests to determine if a redesign of the quadrant is necessary.

Wire Strike. Explore the feasibility of adding wire-strike protection to the V-22 fleet. Consider making this protection a user/field installation item.

STATEMENT OF FINALITY

As discussed, the DOD's skillful acquisition of the V-22 Osprey is critical to the defense of the US. The tilt-rotor V-22, a hybrid helicopter/transport aircraft, will give us the ability to insert combat power into previously impossible-to-reach regions. Besides giving us a viable deterrence, the Osprey will give us the military power to win against terrorist groups and hostile third-world nations during a difficult crisis such as the Iran hostage situation.

In addition to the potential engineering shortcomings identified in Chapter Three, the Osprey's new technologies have potential for even more problems. In many cases, the resolution of these problems will be beyond the scope of the aircraft's long-term fixed-price contract. Considering the severe constraints of the V-22's current acquisition strategy, it is imperative that the PM adopt a more flexible and farsighted acquisition strategy. It is imperative that the PM adopt a highly successful "tried and tested" strategy similar to the Air Force's F-16 strategy.

BIBLIOGRAPHY

A. REFERENCES CITED

Books

1. Air University, ACSC. Low-Intensity Conflict: The Hidden Challenge. Warfare Studies. USAF. Maxwell AFB, AL. August 1987.

2. Air University, AFIT. Introduction to Acquisition Management. System 100 Workbook. USAF. Wright Patterson AFB, OH. 1987.

3. Beckwith, Charlie A. and Knox, Donald. Delta Force. New York City, N. Y.: Harcourt Brace Jovanovich., 1983.

Articles and Periodicals

4. Bulban, Erwin J. "Tilt-Rotor Toolup: Bell Prepares to Give Wing to the V-22." Rotor & Wing International, 8 July 1986, pp. 46-47 and p. 64.

5. Hanley, Art. "Tilt Rotor Prospects Are on the Rise." Aerospace America, October 1987, pp. 6-8.

6. Polsky, Debra. "Ambrose, Officals Differ on Army V-22 Participation." Army Times, 7 December 1987, p. 29.

7. Starr, Barbara. "Army Pullout From V-22 Program No Danger to Tilt-Rotor Osprey." Army Times, 15 February 1988, p. 30.

Official Documents

8. American Institute of Aeronautics and Astronautics. NASA International Aerospace Abstracts. January 1986 through December 1986.

9. Bell-Boeing. V-22 FSD Crashworthiness Assessment.

Report No. 901-919-019, 29 April 1986.

10. Department of Defense. Joint Service Operational Requirement (JSOR) for the JVX (V-22). April 1985.

11. Department of Defense. Military Standard Light Fixed and Rotary Wing Aircraft Crashworthiness. MIL-STD 1290. 25 June 1974.

12. Department of Defense. Tanks, Fuel, Crash and Restraint, Aircraft. MIL-T-STD 27422. 13 April 1971.

Unpublished Materials

13. U. S. Army Aviation Systems Command, AMSAV-ED. Letter, Subject: Bell-Boeing Report No. 901-919-019, V-22 FSD Crashworthiness Assessment Report. 29 July 1986.

14. U. S. Army Safety Center. Army Aircraft Mishap Reports: Class A Mishaps. 1 July 1980 thru 1 August 1986.

Other Sources

15. Air University, AFIT. Manufacturing Management. Introduction to Acquisition Management Film. Film No. F3205-86-0056. Wright Patterson AFB, OH. April 1986.

16. Bell-Boeing. "Joint Services Advanced Vertical Lift Aircraft Program." Briefing slides. Undated (May 1986).

17. Conner, MAJ, USAF. F-16 SPO Integration, AFSC, Wright-Patterson AFB, OH. Telephone interview. Subject: "F-16 Acquisition Strategy." 21 January 1988.

18. Diamond, LTC, USA. U. S. Army V-22 PM Liaison Officer to V-22 PM Office, NAVAIR. Notes. Subject: "NAVAIR's Response to the U. S. Army Safety Center's Assessment of the V-22." Undated (November 1986).

19. Hicks, James E., PhD, GM-14, USA. Chief, USASC Systems Engineering Division. Telephone interview. Subject: "Army Pullout From the V-22 Program." 9 February 1988.

20. Martinez, Randy, MAJ, USAF. ACSC Student/Experienced C-

130 Flight Examiner. Interview. Subject: "C-130's Tactical Refueling Capability." 25 January 1988.

21. O'Connor, MAJ, USA. CH-47/V-22 Program Manager Office, AMCPM-CH-47M. Telephone interview. Subject: "V-22 Lead-Acid Battery." 11 August 1986.

22. Ratcliff, Ron, LTC, USA, USASC V-22 Project Officer/Engineer. Telephone interview. Subject: "Status of the V-22 Program." 10 December 1987.

23. Robinson, CW4, USA, C-12 pilot, USASC, PESC-SPG. Interview. Subject: V-22 Weather Radar Requirement. 8 August 1986.

24. Schelecher, V-22 Class Desk Officer, NAVAIR, Crystal City, VA. Telephone interview. Subject: "V-22 Acquisition Strategy." 10 December 1987.

25. Shepard, William, MAJ, USAF. Lecture presented at Air Command and Staff College, Maxwell AFB, AL. Subject: "Role of Air Power in LICs." 14 December 1987.

26. Snyder, John, AVSCOM Electrical Engineer, AMSAV-ED. Telephone interview. Subject: "V-22 Lead-Acid Battery." 11 August 1986.

27. U. S. Naval Air Engineering Center. Meetings between U.S. Military and V-22 contractors. Subject: V-22 System Safety Working Groups. December 1984 thru May 1986.

28. U. S. Naval Air Engineering Center. Meeting between U. S. Military and V-22 Contractors. Subject: "System Safety Working Group No. 8." Philadelphia, PA. 6-7 May 1986 and Meeting between U. S. Military and V-22 Contractors. Subject: "System Safety Working Group No. 9." Ft. Worth, TX. 7-8 October 1986.

29. U. S. Naval Air Engineering Center. Meeting between U. S. Military and V-22 Contractors. Subject: "System Safety Working Group No. 10." Philadelphia, PA, 3-4 February 1987.

30. Vickery, Jim, MAJ, USA, ACSC LIC Phase Manager, Maxwell AFB, AL. Interview. Subject: "LICs." 15 December 1987.

to ACSC Introduction to Acquisition Management Elective Course. Subject: "Contracts". 20 January 1985.

B. RELATED SOURCES

Official Documents

U. S. Army Training and Doctrine Command, ATZQ-CDM-S. Document. Subject: "(U) Operational and Organizational (O&O) Plan for the V-22 Osprey." July 1984.

U. S. Army Safety Center, PESC-SE. Technical Report 83-8. Subject: "Projected Accident Cost for the LHX Aircraft." September 1984.

U. S. Army Safety Center, PESC-SE. Technical Report (Draft). Subject: "Safety Substudy for the LHX Cost and Operational Effectiveness Analysis (COEA)." January 1986.